PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04B

A2

(11) International Publication Number: WO 95/24773

(43) International Publication Date: 14 September 1995 (14.09.95)

(21) International Application Number: PCT/FI95/00121

(22) International Filing Date: 3 March 1995 (03.03.95)

(30) Priority Data:
941071 7 March 1994 (07.03.94) FI

(71) Applicants (*for all designated States except US*): NOKIA TELECOMMUNICATIONS OY [FI/FI]; Mäkkylän puistotie 1, FIN-02600 Espoo (FI). NOKIA MOBILE PHONES LTD. [FI/FI]; Nakolankatu 8, FIN-24100 Salo (FI).

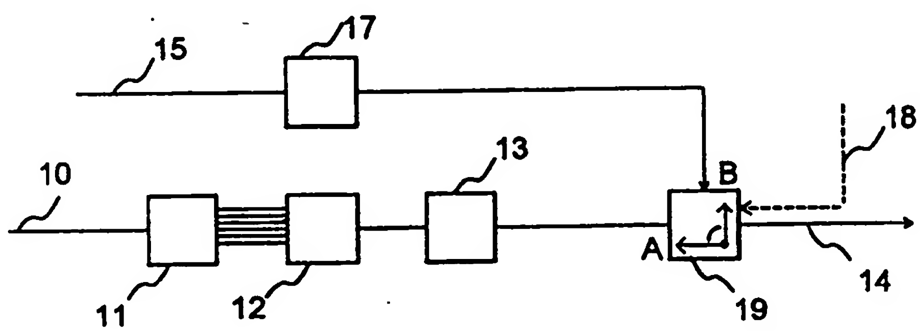
(72) Inventors; and
(75) Inventors/Applicants (*for US only*): OJANPERÄ, Tero [FI/FI]; Tornipolku 8 B 41, FIN-90100 Oulu (FI). RIKKINEN, Kari [FI/FI]; Suotie 19 D 23, FIN-90650 Oulu (FI). KESKITALO, Ilkka [FI/FI]; Koskitie 5 A 8, FIN-90500 Oulu (FI).

(74) Agent: TEKNOPOLIS KOLSTER OY; c/o Oy Kolster Ab, Iso Roobertinkatu 23, P.O. Box 148, FIN-00121 Helsinki (FI).

(81) Designated States: AU, CN, DE, GB, JP, NO, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
In English translation (filed in Finnish).
Without international search report and to be republished upon receipt of that report.

(54) Title: A DATA TRANSMISSION METHOD, TRANSMITTER, AND RECEIVER



(57) Abstract

The invention relates to a transmitter, a receiver, and a data transmission method, in which data bits are modulated prior to transmission by means of multilevel orthogonal or biorthogonal modulation. In order to ensure reliable transmission of information, extra information is transmitted along with multilevel data symbols, said extra information being represented by similar multilevel symbols as data symbols, and being employed for transmitting power adjustment messages or phase reference information.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	GB	United Kingdom	MR	Mauritania
AU	Australia	GE	Georgia	MW	Malawi
BB	Barbados	GN	Guinea	NE	Niger
BE	Belgium	GR	Greece	NL	Netherlands
BF	Burkina Faso	HU	Hungary	NO	Norway
BG	Bulgaria	IE	Ireland	NZ	New Zealand
BJ	Benin	IT	Italy	PL	Poland
BR	Brazil	JP	Japan	PT	Portugal
BY	Belarus	KE	Kenya	RO	Romania
CA	Canada	KG	Kyrgystan	RU	Russian Federation
CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CG	Congo			SE	Sweden
CH	Switzerland	KR	Republic of Korea	SI	Slovenia
CI	Côte d'Ivoire	KZ	Kazakhstan	SK	Slovakia
CM	Cameroon	LI	Liechtenstein	SN	Senegal
CN	China	LK	Sri Lanka	TD	Chad
CS	Czechoslovakia	LU	Luxembourg	TG	Togo
CZ	Czech Republic	LV	Latvia	TJ	Tajikistan
DE	Germany	MC	Monaco	TT	Trinidad and Tobago
DK	Denmark	MD	Republic of Moldova	UA	Ukraine
ES	Spain	MG	Madagascar	US	United States of America
FI	Finland	ML	Mali	UZ	Uzbekistan
FR	France	MN	Mongolia	VN	Viet Nam
GA	Gabon				

A data transmission method, transmitter, and receiver

The invention relates to a data transmission method in which data bits are modulated prior to transmission by means of multilevel orthogonal or biorthogonal modulation.

In a cellular communications system, in addition to user speech or data information, other extra information, such as power adjustment commands or other control messages, is transmitted between a base station and a mobile station. This extra information is transmitted constantly during a speech connection, normally through a traffic channel.

In prior art methods employing multilevel modulation, extra information is transmitted on a traffic channel by replacing convolution coded data symbols with information to be transmitted. This is described e.g. in EIA/TIA Interim Standard: Mobile Station-Base Station Compatibility Standard for Dual-Mode Wideband Spread Spectrum Cellular System, TIA/EIA/IS-95, July 1993.

In prior art methods e.g. a power adjustment message can comprise only one of the two possible values: a power increase or power reduce command. Rough adjustment of this kind is not always sufficient in rapidly changing situations. Furthermore, interference occuring on the radio path may easily cause interference to extra information bits.

It is an object of the present invention to realize a more reliable method than heretofore for transmission of extra information, also enabling transmission of a larger amount of information between a mobile station and a base station.

This is achieved with the data transmission method of the kind set forth in the introduction, which

is characterized in that extra information is transmitted along with multilevel data symbols, said information being represented by similar multilevel symbols as data symbols, and that the extra information to be transmitted is employed for transmission of power adjustment messages or phase reference information.

The invention also relates to a transmitter which comprises means for modulating the data bits to be transmitted by means of multilevel orthogonal or biorthogonal modulation, and means for interleaving the modulated symbols. The transmitter of the invention is characterized in that the transmitter comprises means for modulating bits containing power adjustment messages or phase reference information by employing multilevel modulation corresponding to that employed for data bits, and means for selecting either a multilevel symbol containing data bits or a multilevel symbol containing power adjustment messages for transmission at each given time.

The invention further relates to a receiver comprising means for demodulating and decoding the received multilevel orthogonal or biorthogonal symbols, and means for deinterleaving the received signal. The receiver of the invention is characterized by comprising means for separating symbols containing power adjustment messages or phase reference information from data symbols.

Thus, in the method of the invention, the extra information to be transmitted is described, like data bits, with multilevel symbols transmitted along with the data bits. In accordance with a preferred embodiment of the invention, extra information is transmitted by replacing a data symbol with a multilevel symbol containing the extra information. In accordance with another embodiment of the invention, symbols containing

extra information are inserted in between the data symbols.

When multilevel modulation is employed, transmission of extra information is less sensitive to interference caused by the transmission path, and thus more reliable than when conventional methods are used. On the other hand, multilevel modulation allows an increase in the amount of transmitted information, since several consecutive information bits may be described with one multilevel symbol. When e.g. power adjustment messages are transmitted, more information on the desired power change can be transmitted than a mere power increase or power reduce command. In such a case, however, the reliability of the transmission is not improved compared with prior art methods.

In addition to transmission of power adjustment commands, the invention can also be implemented e.g. for transmission of phase reference information required by coherent detection.

In the following, the invention will be described in greater detail with reference to the examples in accordance with the accompanying drawings, in which

Figures 1a-1c show two methods for transmission of extra information in a frame structure,

Figure 2 is a block diagram illustrating the structure of a transmitter of the invention

Figure 3 is a block diagram illustrating the structure of a transmitter of the invention in greater detail, and

Figures 4a and 4b are block diagrams illustrating the structure of a receiver of the invention.

Thus, the solution of the invention may be implemented in a telecommunications system employing

orthogonal or biorthogonal modulation. In these modulation methods, information bits are modulated to multilevel orthogonal or biorthogonal symbols. In addition to the above mentioned publication, methods for multilevel modulation are described in greater detail e.g. in Finnish Patent Application 935047. In the data transmission method of the application, the signal to be transmitted is encoded by a combination of convolution code and biorthogonal modulation. A serial form signal to be transmitted may be converted such that per each data bit, m+1 parallel form code bits b_0-b_m are obtained. Bits b_1-b_m of the above code bits determine one of 2^m possible orthogonal symbols, the symbol consisting of 2^m parallel binary symbols, and code bit b_0 determining the sign of said orthogonal symbol. Finally, 2^m parallel binary symbols are converted to serial form for transmission. In the present invention, the extra information to be transmitted is encoded, like the actual user data bits, e.g. by means of the method described above, and transmitted along with the data bits, either by inserting the information in between the data bits, or by replacing some part of the data bits with information bits.

Figures 1a, 1b and 1c illustrate different embodiments of the invention for transmitting extra information, from the point of view of the frame structure. Figure 1a shows a normal frame structure, which comprises consecutive data symbols 1,2,3, and 4 to be transmitted. Figure 1b shows an alternative, in which data symbol 2 has been replaced with symbol x containing extra information. Replacing data symbols naturally causes a slight impairment of the signal quality at the receiving end. Figure 1c, again, shows an embodiment in which symbol x containing extra information has been inserted in between data symbols

1 and 2. As the extra information is inserted along with the actual data in this way, the bandwidth of the signal to be transmitted expands.

The structure of a transmitter of the invention is thus illustrated by a block diagram in figure 2. First of all, data bits 10 to be transmitted, which may be user speech or data bits, are applied to a convolution coder 11, which may typically be e.g. a serial to parallel converter, from the output of which the signal is applied in a parallel form to a multilevel modulator 12, which may be e.g. a Walsh modulator. In the modulator, a group of input bits are described with one multilevel symbol, which may be e.g. an orthogonal or a biorthogonal symbol. The output of the modulator has been connected to interleaving means 13, in which the signal to be transmitted is interleaved to reduce the effect of transmission path interference.

Extra information 15 to be transmitted is applied to a multilevel modulator means 17, which corresponds to the modulator means 12 employed for the user data signal. The extra information to be transmitted may be either a single bit or multilevel information, such as a dB power value. In the modulator, one or more extra information bits are described with a single multilevel symbol. A clock signal 18 controls a switch means 19, which controls the transmission of the extra information. When user data symbols are transmitted, the switch is in position A. Normally, one extra information symbol is transmitted at a time. When the clock signal 18 indicates the extra information symbol is to be transmitted, the switch turns to position B.

Extra information, such as power adjustment commands, is usually transmitted at regular intervals. Thus, the clock signal 18 may be a pulse given at

certain fixed intervals. Power adjustment commands are time-critical messages, and thus cannot be applied through an interleaving block 13 due to delay requirements.

The detailed structure of the transmitter of the invention naturally depends on the encoding/modulation method employed in the system. When applying the invention in a system in which the signal is encoded by a combination of a convolution code and biorthogonal modulation, blocks 11 and 12 of the transmitter described above, as well as block 17, may be in accordance with e.g. figure 3.

In figure 3, a signal 20 to be transmitted is applied to a convolution coder 21, which can be implemented e.g. with a k+1 bit shift register. The content of the shift register memory can be expressed as the vector $a = (a_0, a_1, \ldots a_k)$. Per each input data bit, the output of the convolution coder provides m+1 code bits 22, which may be denoted by $b_0, b_1, \ldots b_m$, and which in the above figure are the last k+1 input bits, i.e. k is equal to m. It is also possible that k is greater than m, and that the output bits are not in the same order as the bits inputted in the coder, and that the output bits do not directly correspond to the bits inputted in the coder, but are their XOR sum combinations.

A biorthogonal modulator 23 has been implemented in two phases, orthogonal modulation being carried out first, and biorthogonal modulation of the resulting symbol being carried out thereafter.

Code bits $b_1 \ldots b_m$ provide an input for an orthogonal modulator 50, the output of which provides, as a function of code bits, one of the $M=2^m$ possible orthogonal symbols, said symbol comprising M parallel

binary symbols 51. The i^{th} transmitted orthogonal symbol (i.e. signal queue) x_i may be defined with a formula

$$x_i = (x_{i,0}, \ldots x_{i,M-1})$$
$$= S_j$$

in which index j is defined on the basis of m code bits with a formula

$$j = b_1 * 2^0 + b_2 * 2^1 + \ldots b_m * 2^m.$$

The M-level set of symbols (S_j) may be e.g. an M-level set of Walsh symbols. In such a case, the set of symbols may be described by a Walsh-Hadamard matrix, in which each row of the Walsh-Hadamard matrix represents one possible symbol S_j.

Code bit b_0 is employed for determining the sign of the obtained orthogonal symbol, e.g. by employing the code bit as an input in calculation 26 of the sign, so that when b_0 is 1, the output of means 26 is -1, and when b_0 is 0, the output of means 26 is +1. The binary symbols at the output of the modulator can be multiplied by the output of means 26 in a multiplier 25, which results in M binary symbols 24, defining now a 2^{m+1} level signal. Thus, an M-level orthogonal set of symbols is expanded to a 2M-level biorthogonal set of symbols. The symbol to be transmitted may be one of the M-level Walsh signals or its negative equivalent. In a converter 27, the signal is converted to a serial form. The actual data is applied from modulation means 12 to the interleaving means 13, and extra information is applied from modulation means 17 to the switch means 19.

Both the actual data signal and the extra information are thus processed similarly in a transmitter of the invention.

The structure of a receiver in accordance with the method of the invention is illustrated with block diagrams in figures 4a and 4b. The receiver comprises means 31 and 32 for demodulating and decoding the

received signal, and means 33 for deinterleaving. Let us first study figure 4a showing a receiver realizing a preferred embodiment of the invention. A received signal 30 is first applied to a switch means 35, which is controlled by a clock signal 34. The switch means is employed for separating symbols containing extra information from data symbols, which, subsequent to deinterleaving 33, are applied to demodulation and decoding means 31 and 32, which may typically be e.g. a Walsh-Hadamard converter and a Viterbi decoder. Thus, the symbols containing extra information are separated from the remaining signal prior to the interleaving and the Walsh-Hadamard converter.

Figure 4b shows a receiver realizing another preferred embodiment of the invention, the receiver comprising switch means 37 and 38 controlled by the clock signal 34, said switch means allowing separation of the symbols containing extra information from the remaining signal prior to deinterleaving 33. In this embodiment, symbols containing extra information are applied to the demodulation means 31, which is typically a Walsh-Hadamard converter, as above. The receiver further comprises switch means 39 controlled by the clock signal 34, said switch means guiding the extra information further to processing prior to the Viterbi decoder 32. If extra symbols are replacing data symbols, zero values are fed into the Viterbi decoder instead of an extra symbol. If extra symbols have been inserted in between data symbols, the Viterbi decoder is not timed during the extra symbols, but it will wait for the following actual data symbol.

As with the transmitter, the detailed structure of the receiver of the invention depends on the coding/modulation method employed in the system.

Even though the invention has been explained above with reference to an example in accordance with the accompanying drawings, it is obvious that the invention is not restricted to it, but can be modified in a variety of ways within the scope of the inventive concept disclosed in the attached claims.

Claims:

1. A data transmission method in which data bits are modulated prior to transmission by means of multilevel orthogonal or biorthogonal modulation, c h a r a c t e r i z e d in that extra information is transmitted along with multilevel data symbols, said information being represented by similar multilevel symbols as data symbols, and that the extra information to be transmitted is employed for transmission of power adjustment messages or phase reference information.

2. A method as claimed in claim 1, c h a r a c t e r i z e d in that the information symbols to be transmitted are inserted in between the data symbols as extra symbols.

3. A method as claimed in claim 1, c h a r a c t e r i z e d in that each information symbol to be transmitted replaces one data symbol.

4. A transmitter which comprises means (12) for modulating the data bits to be transmitted by means of multilevel orthogonal or biorthogonal modulation, and means (13) for interleaving the modulated symbols, c h a r a c t e r i z e d in that the transmitter comprises means (17) for modulating bits containing power adjustment messages or phase reference information by employing multilevel modulation corresponding to that employed for data bits, and means (19) for selecting either a multilevel symbol containing data bits, or a multilevel symbol containing power adjustment messages for transmission at each given time.

5. A receiver comprising means (31, 32) for demodulating and decoding the received multilevel orthogonal or biorthogonal symbols, and means (33) for deinterleaving the received signal, c h a r a c t e r i z e d in that the receiver comprises means (35, 37,

38, 39) for separating symbols containing power adjustment messages or phase reference information from data symbols.

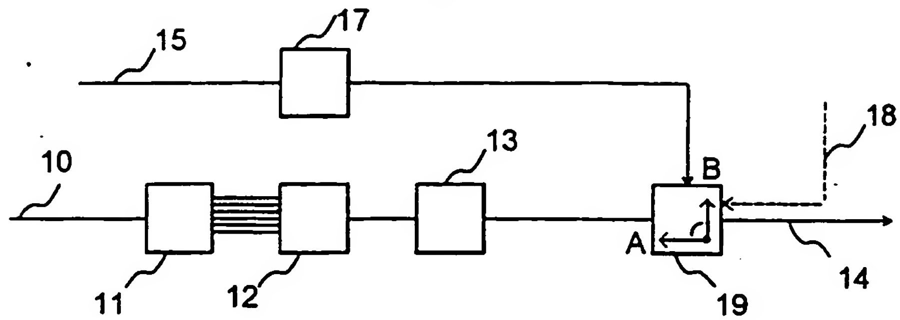


FIG. 2

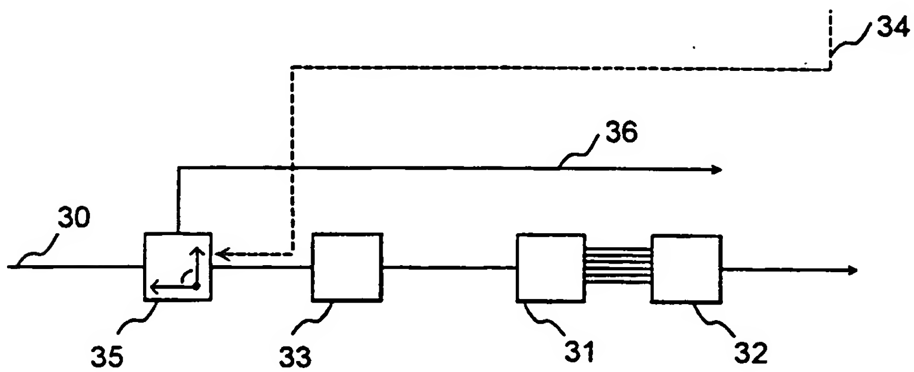


FIG. 4a

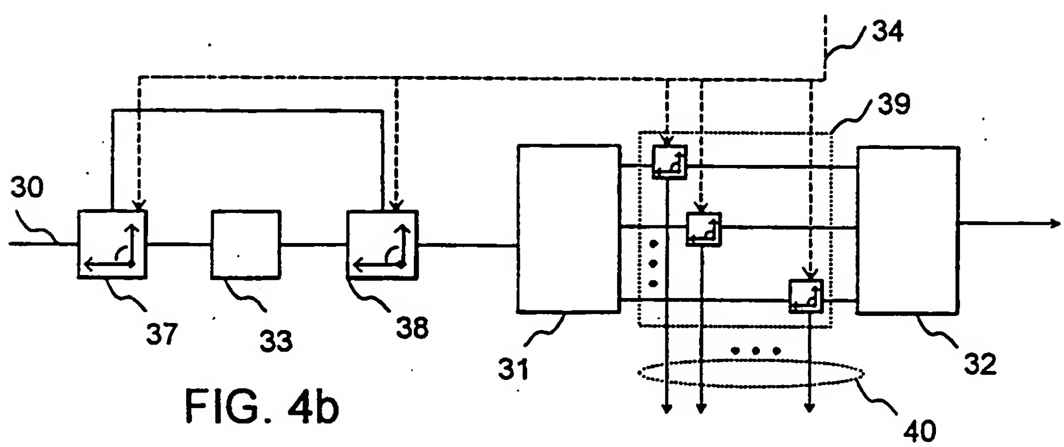


FIG. 4b

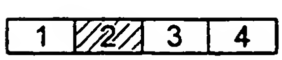


FIG. 1a

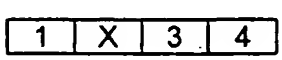


FIG. 1b

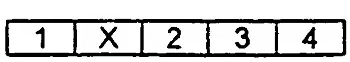


FIG. 1c

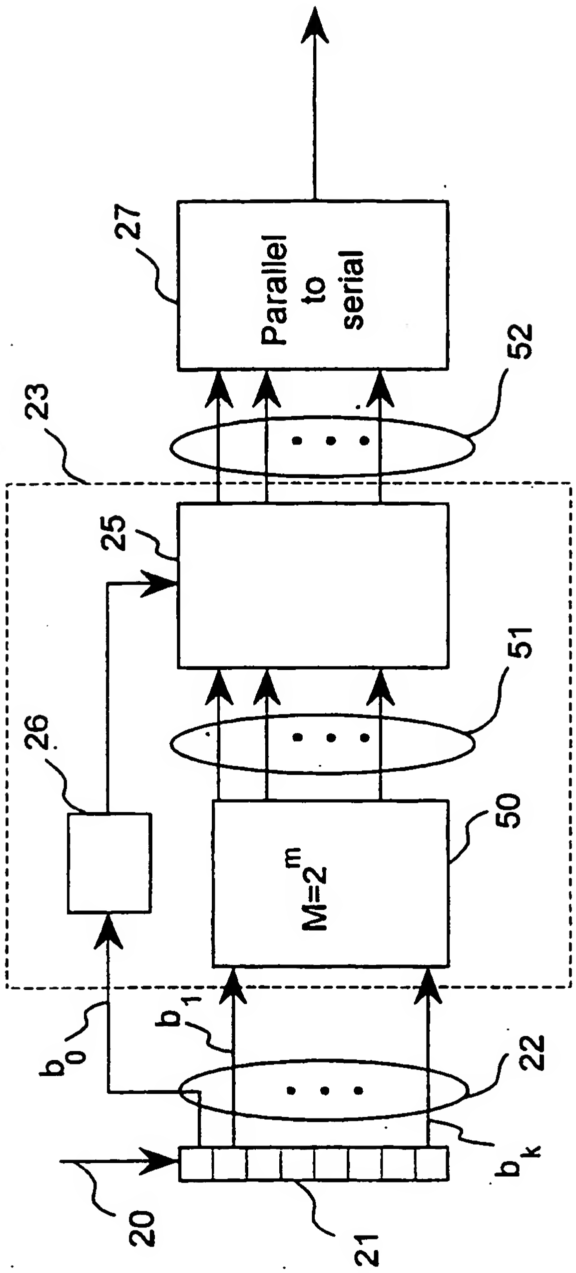


FIG.3